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Announcement of
AWARDS IN RADIOLOGICAL RESEARCH
of the James Picker Foundation

On behalf of the James Picker Foundation, the National Academy of Sciences - National Research Council announces the continued availability of funds in support of radiological research. Applications are reviewed by the Committee on Radiology of the Academy - Research Council's Division of Medical Sciences. Final determination of awards is made by the Foundation upon recommendation of the Division.

In line with the interests of the Foundation, the program is oriented toward, but not necessarily limited to, the diagnostic aspects of radiology. Worthy applications in the field of veterinary radiology will be accepted and considered on their merits. Support is not restricted to citizens of the United States or to laboratories within this country.

Three specific types of support are offered:

(1) *Grants-in-aid* are designed to encourage investigations offering promise of improvement in radiological methods of diagnosis or treatment of disease. Research grants are awarded to institutions, rather than to individuals.

(2) *Grants for Scholars* are a transitional form of support, designed to bridge the gap between the completion of fellowship training and the period when the young scientist has thoroughly demonstrated his competence as an independent investigator. The application is submitted by the institution on behalf of the prospective Scholar. If the request is approved, a grant of $6,000 per year will be made directly to the institution as a contribution toward the Scholar's support, or his research, or both. Initial grants are limited to one year, but renewal for two additional years may be recommended.

(3) *Fellowships in Radiological Research* are open to candidates seeking to gain research skills leading to investigative careers in the field of radiology. While persons from closely related disciplines are eligible to apply, candidates whose training has been directly in the field of radiology will receive preference under this program. Candidates must hold the M.D., Ph.D., or Sc.D. degree or the equivalent. Preference will be given to applicants who are thirty-five years of age or less.

Applications in these three categories for the fiscal year 1958-1959 should be submitted by December 1, 1957. Further details and application blanks may be obtained from the *Division of Medical Sciences - Room 309, National Academy of Sciences - National Research Council, 2101 Constitution Avenue, N. W., Washington 25, D.C.*

The National Research Council of Canada will in the near future assume the responsibility for serving as scientific adviser to the James Picker Foundation with respect to its Canadian program.

THE JOURNAL OF THE
CANADIAN ASSOCIATION OF RADIOLOGISTS

Volume VIII September 1957 Number 3

THE GORDON RICHARDS MEMORIAL LECTURE
On
THE SPONTANEOUS REGRESSION OF CANCER*

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Part I

INTRODUCTION

I am indeed honoured to be asked to give this lecture in memory of my friend and former colleague, Gordon Richards. Those who have preceded me in other years, more particularly Dr. Jones of Kingston last year, have dealt so fully with Dr. Richards' character and work that I shall not take up your time by travelling over the same ground again.

There was no subject in which Richards was more interested than that of cancer, so I have chosen one aspect of that disease for our discussion. What I have to say may be received by many of you with incredulity if not with derision.

When we think of cancer we are likely to conjure up a process characterized by a steady, remorseless and inexorable progress in which the disease is all-conquering, and the faltering footsteps to the grave are not arrested by any of the defense forces which help us to survive the onslaught of bacterial and viral infections. And yet the arresting title of Sampson Handley's paper in 1909 is "The Natural Cure of Cancer", although the approach was quite different from that of the present communication. The inadequacy of the view alluded to above becomes apparent whenever we look back on our own experience. We know that whilst some cancers are fearfully rapid in their course, others are incredibly slow. A slow-growing tumour may suddenly start to grow quickly, either for an apparent reason as in the accelerated growth of cancer of the breast during pregnancy, or for no apparent reason. On the other hand, although much more rarely, the rate of growth of a tumour will slow down to a marked degree. Finally, and still more rarely, growth may stop completely, and the neoplasm, both primary and secondary, may resolve and eventually disappear. True, all reports of such cases must be looked at critically if not skeptically, but to shut our eyes and refuse to believe in the spontaneous regression and recovery from cancer is as absurd as the attitude of Pasteur's and Lister's critics, who refused to see the evidence so plainly demonstrated to them.

A name for these tumours has been suggested by Charteris[1] in the following passage: "On this subject, about which so little is actually known, it seems fairest to recall reverently St. Peregrine, the cancer saint. As a young priest, he suffered a cancer of the leg and was scheduled for operation. The night before, he prayed fervently to be saved from amputation and he dreamed that he was cured. On awakening, he discovered that it was more than a mere dream — he *was* completely cured. He lived to his 80th year, dying in 1345 without further evidence of cancer. During his life he dedicated himself to the relief of such suffering, and he was canonized St. Peregrine in 1726. Perhaps we could term tumours that disappear spontaneously 'St. Peregrine Tumours.' "

When we speak of regression of a malignant neoplasm we must distinguish between partial and complete regression. From the standpoint of the patient there is of course all the difference in the world between the two, but to the inquiring mind the distinction is not so fundamental, for in both there is evidence of some defense force, healing process, immunological reaction, call it what you will.

Striking proof of the existence of some form of restraint mechanism either in the neoplastic cells or in the environment which surrounds these cells is offered by (1) the occasional long delay before metastatic growths manifest themselves, and (2) the occurrence of cases of latent cancer.

Before proceeding to an examination of individual instances it will be well for a few moments to examine the meaning and content of the term "spontaneous." The dictionary

*Presented at the Annual Meeting, The Canadian Association of Radiologists, January 17, 1956, Vancouver.

defines it as occurring without external cause. I would ask your permission to modify that by adding the qualifying adjective, "adequate." When a malignant tumour has been removed in toto or when it has been overwhelmed by radiation the subsequent recovery is of course in no sense spontaneous. If, on the other hand, only a part of the cancer has been removed, or if the radiation has been completely inadequate, it is surely justifiable to describe the regression and disappearance of the remainder of the tumour as spontaneous, for it cannot be attributed to any adequate external cause. It is a curious and perhaps significant fact that in many of the recorded cases some such partial and half-hearted interference has been attempted. It would almost appear as if such procedures had triggered a mechanism or started a chain reaction which cut short the neoplastic process and resulted in the downfall of the tumour. Severe febrile attacks such as erysipelas and the use of Coley's fluid may be included in this category. Perhaps in such cases we are justified in speaking of induced regression.

Let us now review briefly some of the cases of spontaneous regression encountered by myself, communicated to me by others, or recorded in the literature.

ILLUSTRATIVE CASES

Neuroblastoma

The most striking example of spontaneous regression of a malignant neoplasm is afforded by neuroblastoma, usually of the adrenal medulla, sometimes of the para-vertebral ganglia. *M.A.*, aged 9 months, had an adrenal neuroblastoma removed in part at the Hospital for Sick Children, Toronto, but the remainder had to be left in the abdomen. She was sent home to die without any further treatment. The tumour gradually disappeared and the child is now alive and in perfect health 12 years after the operation. She is, indeed, taller than her twin sister.

Uhlmann and von Essen[2] report seven patients with neuroblastoma alive and well for periods of 13 years to 22 months after radiation alone, 5 of whom had metastases at the time of treatment. In at least some of these instances they consider it highly improbable that cancerocidal doses of radiation reached all of the tumour cells.

Bodian[3] reports a mortality of 75 per cent within 6 months in 77 cases of neuroblastoma, proof of the highly malignant character of this tumour of childhood. In two cases, however, there was spontaneous regression and apparent cure. One young child was admitted in 1933 with a mass in the axilla. This was excised and found to be a secondary neuroblastoma. Radium was applied superficially. The site of the primary tumour remained unknown. The patient was alive and well in 1954, 21 years later. The second patient was seen in 1947, with an intra-abdominal tumour, a grossly enlarged liver, and subcutaneous nodules which proved to be deposits of neuroblastoma. As the case was regarded as hopeless, no treatment was given, but the patient was alive and well in 1954.

The neoplasm may either disappear or be converted into a tumour of benign type. Thus Cushing and Wolbach[4] in 1927 reported a case of a child 2 years of age with neuroblastoma of the para-vertebral ganglia, which 10 years later had become differentiated into ganglion and neurilemmal cells of adult type. It would appear that a mild degree of radiation may promote or accelerate this process of maturation.

Stewart[5] in his Bertner Lecture, which deals with the general subject of the spontaneous regression of cancer, reports 3 cases of neuroblastoma. The first was an infant a few months' old with neuroblastoma and skin metastases discharged as hopeless. The nodules in the skin began to disappear, and the patient was well 5 years later. The second case was an infant with metastatic neuroblastoma in the upper end of the femur. The metastasis was treated by radiation, and the child was in excellent health 14 years later. The third case, not seen by Stewart personally, was perhaps the most remarkable. A large abdominal mass was present at birth; it extended from the costal margin to the iliac crest and across the mid-line. Multiple skin metastases developed all over the body and on the head. The diagnosis was confirmed by biopsy. The only treatment given was a little nitrogen mustard for 4 days. No effect was observed during a month's observation in hospital. Six weeks after discharge the abdominal mass began to shrink, and the skin nodules to disappear, and 7 months after being first seen the child appeared to be in good health. Later, however, new skin nodules are said to have developed.

Malignant Melanoma

Malignant melanoma is a tumour of so discouraging a character that it is perhaps surprising to encounter reports of spontaneous regression. On the other hand when we recall how benign the behaviour (although not the histological picture) of this tumour is before puberty, it is apparent that some biological check on its growth and dissemination is possible.

My colleague, Dr. R. I. Harris of Toronto[6], was asked in 1942 to see a young woman, 33 years of age and 4 months pregnant, who had a malignant melanoma of the thigh. This had developed at the site of a pigmented mole, which had been present since birth but had only commenced to become larger during the period of pregnancy. The tumour was excised and she was delivered of her baby. She was next seen when the baby was 3 months' old, at which time she had an enormous mass of intensely pigmented glands in the groin and a large mass in her liver. The patient was thin and emaciated, obviously with widespread dissemination of the disease, and it was evident that her days were numbered. Dr. Harris was astounded to hear from her doctor three years later that she was not only alive but active and well. The liver had greatly diminished in size, and the mass in the groin was no larger than a hen's egg. "By great good fortune she did not seek the treatment of any quack or exponent of a cancer cure". In 1947 the tumour again became active, and she died in the course of a few months after 5 years of regression. If she had been killed in an accident at the end of 1946 the case could have been regarded as a cure, not merely a regression.

In 1921 I reported two cases of melanoma which showed that a patient may live on relatively good terms with his neoplasm[7]. The first case was a man, aged 71, who was first seen in 1920. In 1913 he had developed a malignant melanoma on the plantar surface of the heel. It was removed, recurred, and was again removed in 1916. Next year the inguinal nodes became enlarged till they formed a pigmented

mass as large as the fist. The primary growth was removed for the third and last time in 1918. At the end of 1919 firm black nodules developed along the leg between the knee and the ankle and other nodules on the chest wall and the side of the nose. A spontaneous fracture of a rib completed the picture. Here, then, was a man who for 7 years had suffered from a highly malignant tumour, during three of which years there was distant lymph node involvement, with spread by the blood stream for nearly a year, yet he remained in excellent health for 6 years, with every prospect of living out the seventh. He certainly appeared to enjoy some form of constitutional immunity which, while it did not inhibit the neoplastic process, did allow the patient to live in a reasonable degree of harmony with his tumour. The outlook in melanoma is not necessarily as black as the nodules.

The next case was an equally striking illustration of the same general truth. A healthy farmer, 38 years of age, presented himself with a pigmented mass in the axilla, which proved on removal to be a typical malignant melanoma. Some 7 years previously a growth of unknown nature had been removed from the back. He made a rapid recovery and did a full summer's work on his farm. In the fall black nodules appeared on the skin of the chest and abdomen. These were excised and showed the same structure as the axillary mass. His health remained unimpaired, but, realizing the seriousness of his condition, he insured his life as a first-class risk! Some 8 months later he reappeared in hospital with acute intestinal obstruction, which was caused by an adherent lymph node enlarged by melanoma. Three months later he again presented himself, this time complaining of a sore throat. His tonsils were converted into two large dark masses which were removed with perfect ease. He returned to his farm and continued to work throughout the winter, but he died suddenly of some unknown cause during the spring. This man thus enjoyed nearly 3 years of robust health doing the strenuous work of a Manitoba farmer, punctuated though they were with periodic operations and riddled as he must have been with malignant cells.

In 1915 Mathews[8] reported the case of a man, aged 42, who came with a melanoma over the scapula, a mass of axillary nodes the size of a small fist which had developed in the course of 5 weeks, and a swelling in the supra clavicular region. The case was regarded as hopeless and death was expected in a few months, but the primary tumour and the axillary mass were removed. The patient made an uninterrupted recovery, returned to his work as an engineer, and was alive and well when last heard from 2 years later.

The last case of malignant melanoma to which I shall refer is that reported by Sumner[9] in 1953, and it is perhaps the most remarkable of all. The incredible story is as follows. A woman, 30 years of age, was first seen in February, 1949, with a lump in the breast which had been there for one year without causing discomfort, but had recently increased rapidly in size and become painful. For 3 years she had noticed a painless lump in the left inguinal region and a similar mass in the left upper arm for 6 months, as well as several small tumours in the abdominal wall and back. It should be noted that she was 5½ months pregnant. The tumours in the breast, the arm and the groin were excised and found to be metastatic malignant melanoma. On being questioned the patient recalled that three and one-half years ago she had had a "black mole", which became infected and disappeared. The case was regarded as incurable, but a few of the larger tumours of the abdominal wall and back were excised in the office under local anaestesia. The deeply pigmented masses proved to be very friable so that they were torn during removal, and a soot-coloured fluid escaped into the wound. "At the completion of this most depressing procedure it was expected that the patient would promptly have a local recurrence with fungating ulceration." What happened was entirely unexpected. All the incisions healed well. There was a normal delivery. In November of 1949 a small mass beneath the scar in the inguinal region was excised, and found to consist of a cavity surrounded by lymph nodes. No tumour cells were found, with the exception of one area which contained a few degenerating melanoma cells. Marked fibrosis and thick-walled vessels suggested to the pathologist the picture following radiation, but no radiotherapy had been used. Next year an enlarged supraclavicular node developed in the right supraclavicular region. This was removed but only in part. In February 1953, 4 years after the patient first presented herself with advanced and widespread metastases, she was apparently completely free of disease.

In this case there could be no possible doubt as to the diagnosis. Treatment was certainly inadequate, and yet regression was complete.

Bronchogenic Carcinoma

Blades and McCorkle[10] report the following remarkable case. In May, 1947, a 59-year-old man presented a typical picture of carcinoma of the lung with an X-ray opacity. He had lost 18 pounds in the past 6 months. An exploratory operation revealed an inoperable carcinoma of the right hilum with invasion of the mediastinum. Biopsy showed an anaplastic epidermoid carcinoma with mitotic figures in all microscopic fields. In May 1952, exactly 5 years later, he was found to be in perfect health. The old lesion had vanished, but an irregular density was observed in the second left interspace, together with a destructive lesion in the skull suggestive of a former metastasis. In December of the same year the condition was unchanged. In a personal communication, October 6, 1955, Dr. Blades informed me that the man died about 6 months previously, which puts the follow-up at over 6 years. He had been apparently in perfect health and was found dead in bed. This appears to be the only recorded instance of spontaneous regression of a bronchogenic carcinoma.

Myosarcoma

D. W. Penner[11] of the Winnipeg General Hospital, reports a case of a 2½ months-old boy who was admitted to the Winnipeg General Hospital in June 1947, with a tumour of the left thigh 5 cm. in diameter which was fixed to the surrounding tissues. X-ray examination suggested a soft tissue tumour eroding the lower end of the femur. Biopsy showed the homogeneous appearance of a sarcoma, extremely cellular, with elongated nuclei and frequent mitoses in each high power field. The diagnosis of sarcoma was confirmed by Stewart and Foote of the Memorial Hospital, New York. No treatment was given. The boy was seen again 5 years later in September 1952, at which time he was in perfect health with no evidence of tumour. The X-ray appearance of the femur was normal, and all sign of the erosion had disappeared.

Stewart[5] in his Bertner Lecture reports a case of wholly inoperable myosarcoma of the uterus, which had spread throughout the pelvis and into the mesentery. Biopsy showed a very soft, vascular, haemorrhagic sarcoma. The lesion was treated by means of radium bomb, but without effect, for the mass did not regress and was evidently not radiosensitive. Just before completion of the treatment a sudden and dramatic change occurred almost in

the matter of a few hours. The patient developed a high fever, an urticarial rash, and a marked eosinophilia, at the same time losing several kilograms of tumour and ascitic fluid in the course of a few days. The tumour disappeared completely and the patient was alive and well 10 years later. Stewart suggests that some alteration took place in the tumour protein, that the patient became sensitized to this protein, and thus developed an intense immune reaction. We shall return to this suggestion later.

Breast

In 1890 Pearce Gould[12] saw a patient with carcinoma of the breast (confirmed microscopically) and widespread metastases in the lymph nodes, the skin, and the neck of the femur leading to a pathological fracture. Nine years later all the lesions had disappeared and the fracture of the femur had healed. When last seen in 1906 she was in good health.

Gould also reports the following two early examples of regression of mammary cancer after oophorectomy. A nurse, aged 46, had a breast removed in 1897 for carcinoma of the breast. There were numerous recurrences in the axilla and skin. These were removed. In 1910 a large mass developed in the axilla. As the condition was inoperable, both ovaries were removed. When seen 10 years later the patient was in excellent health and was regarded as cured.

A woman, 41 years of age, had had cancer of the right breast for two and a half years with ulceration for two years. Biopsy showed scirrhous carcinoma. A tumour now appeared in the left breast and this doubled in size in six weeks. By now the entire right breast and the overlying skin were infiltrated, with involvement of axillary lymph nodes on both sides. Although the condition was hopeless, bilateral oophorectomy was done. The result was startling. In three weeks the ulceration had healed and the metastatic nodules were smaller; in 5 weeks the lump in the left breast could no longer be felt; in 7 weeks all the tumours had disappeared with the exception of a few small skin nodules. Unfortunately she then developed acute intestinal obstruction and died. At autopsy the only signs of tumour were a few small subcutaneous nodules over the right breast.

In 1921 I[7] published the following example of spontaneous regression of metastasis from cancer of the breast. A woman, aged 40, had her breast removed for scirrhous carcinoma in September 1915. The axillary lymph nodes were involved. During the following year she developed secondary growths in the right humerus, the right femur and the pelvis. In October, 1917, she was re-admitted to the Winnipeg General Hospital in a miserable condition, unable to feed herself because of spontaneous fractures of both upper arms, with widespread involvement of the cranium, the humerus, radius, ulna, femur, tibia and fibula on both sides, the pelvis, and the small bones of the hands and feet. "Arrangements were made for the patient to be sent to a home for incurables in another city, but as that institution was full, a delay of four months ensued before she could gain admission. During that time the clinical picture underwent a most extraordinary transformation. The nodules in the head disappeared, fractures of the arms united, strength returned to the legs, she was able to sit up and knit, and by the time she left the hospital she was walking about the ward with a little assistance." Unfortunately a follow-up in this case is not available.

Renal Carcinoma

A number of instances of the spontaneous regression of renal carcinoma (hypernephroma) are on record. Viola Rae's[13] case was a woman, 61 years of age, who on account of gastro-intestinal symptoms was found to have a large fixed mass in the region of the kidney. When this was removed surgically it proved to be a large globular tumour of the upper half of the kidney measuring 13 cm. in diameter. It was stony hard in consistency, so that a saw was required to cut it. A small part of the tumour which remained uncalcified consisted of groups of the characteristic clear cells of renal carcinoma. This is an example of a neoplasm which grew to a certain size, and then underwent necrosis and calcification. The gross specimen may be seen in the University of Toronto Pathology Museum.

Marked degeneration and necrosis, which may be followed by calcification, is an indication that these tumours may be tottering rather than extending. A huge carcinoma involving all but the lowest pole of the kidney was removed from a woman in the Vancouver General Hospital in 1930. The entire specimen weighed 512 grams. A tumour embolus was present in one of the renal vessels. In such a case the outlook would certainly appear dark, but there was very marked degeneration of the tumour cells and great inflammatory cell infiltration. The patient was alive and well in 1955, being 85 years of age.

Teratoma of Testis

I am indebted to Dr. T. A. Watson of Saskatoon for the following report. A man, 35 years of age, was admitted in March, 1954, to the Saskatoon Cancer Clinic, suffering from enlargement of the right testis of 6 weeks' duration. The testis was removed and proved to be the seat of a malignant teratoma composed of solid sheets and irregular acini of large cells with foamy cytoplasm and prominent nuclei. Mitotic figures were numerous. There was invasion of small vascular channels as well as of the epididymis and the tunica albuginea. The paraaortic lymph nodes were dissected out and found to be the seat of secondary growths. X-ray of the chest was normal. In September the patient was found to be in good health and to have gained 9 pounds in weight, but on X-ray examination a rounded density was seen in the right lung, presumably a metastasis. "Although it was considered that this tumour was probably of a radio-resistant nature, a single exposure of cobalt radiation, using parallel-opposing fields, each of 8 x 8 cm., was given to this metastasis, the tumour dose being 800 roentgens. This was given as a sensitivity test. On November 9, 1954, X-ray of the chest showed some increase in size of the secondary deposit in the right lung. On March 15, 1955, X-rays of the chest showed considerable increase in size of the secondary deposit in the right lower lung, and also a new secondary deposit the same size near the left hilum. The patient maintained his good condition, and had no symptoms referable to his chest. On June 7, 1955, the large secondary deposits in the lungs had diminished in size, and on September 6 only a hazy vague increase in density remained in the region of the previous masses. The patient's general condition was still excellent." Dr. Watson adds: "We consider that this is a case of spontaneous regression of secondary deposits in the lung from a teratoma of the testis." He points out that the metastasis on the right side was radiated with fairly small fields, that following the radiation it increased greatly in size, and that the deposit in the left lung received no radiation treatment of any kind.

Carcinoma of Thyroid

It is generally admitted that carcinoma of the thyroid, both the primary tumour and its metastases, may disappear unexpectedly and mysteriously either spontaneously or with inadequate treatment. I am indebted to Dr. Isadore Lampe of Ann Arbor for the record of two cases in which secondary tumours regressed under what he regards as inade-

quate treatment. (1) A 26 year-old woman had had a thyroidectomy some time previously for papillary adenocarcinoma. She presented herself with metastatic lesions in both sides of the neck and in both lungs. Although the situation was regarded as hopeless, radiation treatment was given. "The larger metastatic masses in the left neck received 1500 r as measured in air using 200 Kv. radiation to each of two fields in 12 days, and so-called erythema doses consisting of 600 r as measured in air, given at one time, using Kv. radiation, were given to the right neck and to each of four chest fields." The masses in the neck receded, and in the course of time all evidence of the pulmonary metastases disappeared. Four years after the initial treatment an enlarged node developed in the neck. This subsided under vigorous treatment. The patient is now perfectly well, married and raising a family 12 years after the initial treatment. (2) The second case was very similar. Pulmonary metastases developed three years after thyroidectomy for carcinoma. Two years later the chest was treated with radiation doses similar to those employed in the previous case. Although there is still a suggestion of residual pulmonary lesions, the patient is alive and well seven years after the metastases were first treated. Dr. Lampe adds that while the original doses of radiation were not homeopathic, they could not be described as large.

Dr. George Crile, Jr.[14] of Cleveland writes to me: "I have personally seen at least one case in which pulmonary metastases have remained completely static over a period of thirty years and we have quite a few which have disappeared in response to feeding of desiccated thyroid". In a recent publication he points out that with full replacement doses of desiccated thyroid, the exogenous hormone suppresses the formation of thyroid-stimulating hormone by the pituitary, as a result of which atrophy may develop both in the thyroid and in low grade papillary carcinoma of that gland as well as in any pulmonary metastases.

Chorionepithelioma

This tumour provides many examples of inexplicable disappearance of metastases when the primary growth is removed. One such, reported by Johnson[15], will suffice. Hysterectomy was performed for chorionepithelioma, the biopsy diagnosis being confirmed by A. T. Hertig. A few days later X-ray examination of the chest showed widespread metastases in both lungs. Five months later all signs of the metastases had disappeared nor was there any evidence of them when the patient was again examined after another 10 months.

Carcinoma of Pharynx

A man, 54 years of age, reported by Godfrey[16] in 1910, may be regarded as having suffered from carcinoma of the throat, for when first seen he had involvement of the left tonsil, lateral wall of pharynx and root of tongue by an ulcerating neoplasm. He was emaciated and cachectic, and the nodes on the left side of the neck were enlarged. Regarded as a hopeless case, he was put on opiates and sent home. Later he was taken to London, where he was examined by four surgeons at St. Bartholomew's Hospital and two at the Cancer Hospital, all of whom agreed in the diagnosis, which was confirmed by biopsy. He was given a few months to live. Some 18 months later he returned to his physician. "I did not recognize him, and was thunderstruck when he told me who he was, as I had thought of him as dead." He was in perfect health, with no evidence of any tumour, and the former site of ulceration was replaced by a smooth scar. He said that shortly after returning home and settling his affairs the pain and discharge had ceased and the growth had begun to disappear. The only treatment was gargles and opiates.

Carcinoma of liver

Stewart[5] reports the case of a nurse who developed an abdominal mass. Exploratory laporatomy was done by Dr. Allen O. Whipple, and the mass proved to be a large inoperable malignant hepatoma. The patient recovered without any treatment, but was killed 12 years later in an accident. At autopsy the former lesion was small, shrunken and fibrotic, with traces of a few atrophic tumour cells.

Carcinoma of larynx

I am indebted to Dr. H. K. Fidler of the Vancouver General Hospital for notes on this and the following cases. A man, W. L., developed hoarseness of the voice in 1942 when he was aged 54 years. In 1943 the right vocal cord was found to be thickened and ulcerated, although there were no palpable lymph nodes. Biopsy revealed an epidermoid carcinoma, grade II. The patient refused both surgical and radiation therapy. In 1947 the family doctor reported that the larynx appeared normal. When it was re-examined in 1951 it was again normal. In 1955 the patient was working and free from symptoms. It may be noted that the patient attributes his cure to the ministrations of a herbalist.

Papillary Carcinoma of Ovary

It is well recognized that removal of an ovarian neoplasm may be followed by the disappearance of peritoneal metastases. The following case, also reported to me by Dr. Fidler, is an illustration of this occurrence, but it is noteworthy because the spontaneous regression was marked by a recurrence elsewhere 20 years later. In 1929, when the patient was 46 years old, her right ovary was removed for papillary carcinoma, but as there was extensive peritoneal involvement the case was regarded as hopeless. She made a complete recovery, but in 1949, that is to say 20 years after removal of the ovary, she presented herself with an abdominal mass which proved to be an adenocarcinoma of the left adrenal. In 1950 she developed a mass above the right clavicle, which again was found to be adenocarcinoma. In 1951 she showed evidence of a cord lesion causing paralysis of the bladder and legs, a lesion which cost her her life. At autopsy there was widespread involvement of the dorsal spine and left adrenal by papillary adenocarcinoma, but there was no trace of the original tumour in the peritoneal cavity or the abdominal lymph nodes.

Pelvic Sarcoma

Rohdenburg[17] records a striking case of pelvic malignancy. A woman, aged 37 years, was found to have a large mass arising from the left side of the pelvis. Exploratory laporotomy showed the condition to be hopeless and inoperable. A mass the size of an adult head was attached to the lateral wall of the pelvis and to the sigmoid, whilst innumerable secondary growths were scattered over the peritoneum. One of these nodules was removed and examined microscopically. It was reported as spindle-cell sarcoma. No surgical treatment was undertaken, but the patient slowly improved, the pelvic mass disappeared, and in two years she was in perfect health. When she died 20 years later from uremia, autopsy showed chronic nephritis, but no lesions in the pelvis or abdomen to indicate the former presence of a neoplasm.

(Editor's Note:

This stimulating address by a world famous Canadian pathologist is being printed almost in its entirety because it contains a wealth of experience and many thought-provoking ideas. Canadian radiologists may wish to take exception to some of the individual case reports as to the validity of diagnostic and therapeutic criteria, but the over-all impression is one of a scholarly and fascinating philosophical approach to malignancies.

Second part of The Gordon Richards Lecture, The Spontaneous Regression of Cancer, will appear in the December issue of the J.C.A.R.)

LATE BONE CHANGES IN CAISSON DISEASE

with a

Case Report

C. ROTENBERG, M.D., and A. R. McGEE, M.D.
Toronto, Ontario

The clinical symptoms, early and late physical injuries due to an extreme atmospheric pressure reduction, technically known as "decompression" are infrequently observed. Today, however, this problem is pointed up not only in tunnel occupations and other construction work, but in aviation where with a quick ascent there follows a reduction below the normal. With either of these types of accidents the clinical complex of "bends" may be present.

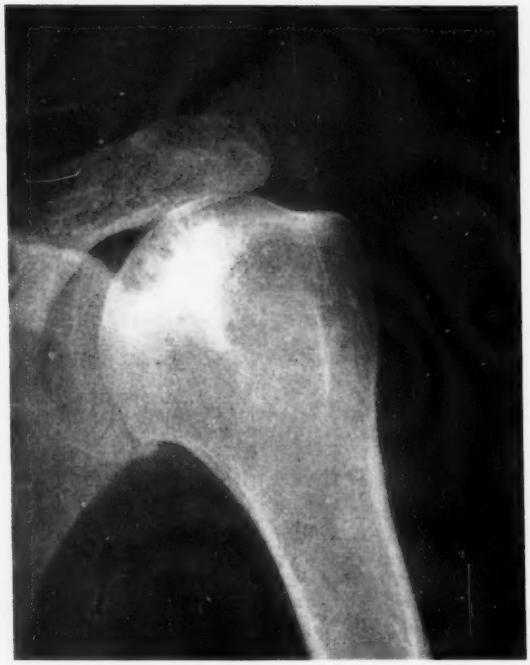

Figure 1. Sclerotic epiphyseal infarct.

It has been established by Bert, Hill and McLeod[1] that all symptoms are due to decompression and not to the mechanical effect of the pressure itself. When an animal is under pressure its tissues dissolve gas according to Dalton's Law, which states that at two atmospheric pressures twice as much gas will pass into solution as at zero pressure[1]. Thus it is found that the resultant illness may be just as severe with a quick reduction below the normal as from a higher pressure to normal.

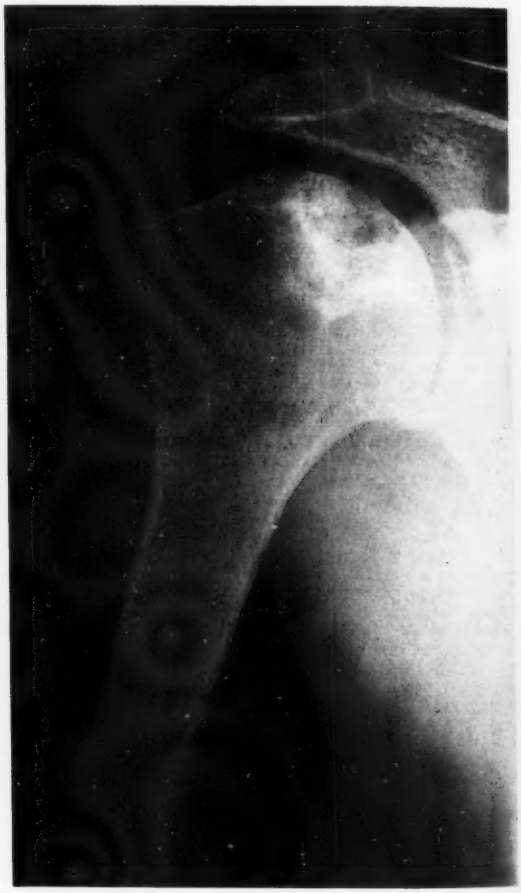

Figure 2. Sclerotic epiphyseal infarct.

Virtually any system in the body may be affected and the extent and location of this determines the type and degree of symptoms; most often involved, however, are the skeletal and cardio-respiratory systems, the spinal cord and brain. There may be any variation from simple joint and muscle pains to nausea, asphyxia, paralysis and death.

Presented at Annual Meeting, The Canadian Association of Radiologists, January 13-17, 1957, Montreal.

Etiology

With an increase of atmospheric pressure there is an increased absorption of gases in the blood and tissues. The fatty tissues are said to dissolve five times as much as water or blood plasma. When the decompression takes place too quickly, the lungs are not able to excrete the excess of nitrogen, though increased oxygen is taken up by the haemoglobin. Consequently, multiple nitrogen bubbles flood the blood stream, and these may act as emboli, blocking smaller vessels, exploding them and causing widespread infarction.[2] Since lipoidal tissues have the greatest notrogen absorption potential, the frequency of involvement of bone marrow, brain, spinal cord and intestinal mesentery is understandable.[2] When the brain or spinal cord is the locale of infarction, symptoms are directed therefrom, and paralysis may be present in varying degrees. Quick death is often circulatory in type and the blood has been described as frothy at autopsy.[3]

Figure 3. Flattened joint surface and osteo-arthritic changes.

Discussion

In this disease the lesions are usually bilaterally symmetrical. Since a bone infarct is not visible by X-ray until macroscopic quantities of hydroxyl apatite are precipitated or until the necrotic area has been demarcated, considerable time may be required. Although late skeletal changes are well defined, it was only recently that five cases exhibiting minor early changes were described. These were about two to five years post accident.

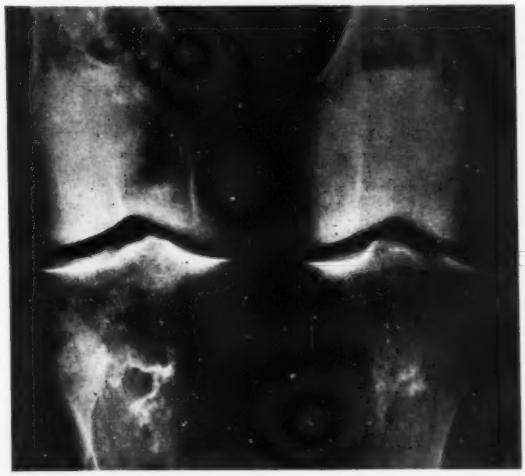

Figure 4. Medullary Calcifications in the lower femora and upper tibial.

Infarcts in tubular bones are most frequently found in the epiphyses and at the ends of the shafts. Mid-shaft lesions are uncommon.

Infarcts tend to occur in the following areas:

(1) Upper end of humerus
(2) Upper end of femur
(3) Lower end of femur
(4) Upper ends of tibia and fibula.

Diaphyseal infarcts involve only the medulla and are visualized as irregular calcifications and/or ossifications. These may be in threads, chains, or clusters of rings and their appearance is quite typical and diagnostic.

The epiphyseal infarcts appear as wedge or tongue-shaped densities which extend to the joint surface. In early cases, a band of radiolucency may be visualized in the subchondral bone. Weight bearing and joint movement tend to produce deformity at the overlying joint surface. Later, bony condensation takes place and if this is marked, a "snow cap" of condensed bone appears at the top of the articular surface. This appearance is most frequently seen in the femoral head. All of the changes associated with aseptic necrosis may develop and later, secondary arthritic changes may occur.

Because of the neighbouring joint, epiphyseal infarcts may produce symptoms of aseptic necrosis and secondary osteoarthritis. Diaphyseal lesions do not produce symptoms as a rule.

Figure 5. Lateral view of the left femur and tibia showing calcification of shaft ends.

Case Report

This case is of particular interest because the patient's period of employment in high pressure work lasted only one-half day, some 25 years ago. He worked in a sewer project where there was pressurization because of water seepage. He recalls that he had a very severe attack of the "bends" on coming out, characterized by excruciating pain in the limbs. He was taken home and was unable to get out of bed for about three days. The few hours mentioned above represent the total time of his labours in any pressurizing occupation and indeed in either sewer or tunnel work. He is now sixty-three years of age. A recent unenthusiastic effort by the patient failed to impress the Workmen's Compensation Board, which is not surprising since he doesn't even remember the name of his employer on that fateful morning.

During the 25-year interim there were no particular symptoms. His present principal complaints are pain and limitation of movement of the left hip.

Physical Examination — revealed some spasticity of gait and limitation of mobility at the left hip. Tendon reflexes were exaggerated on both sides. Laboratory data, including blood smear and Wassermann were negative with hemoglobin 85%.

Figure 6. Lateral view of lower right femur and upper tibia showing calcification of shaft ends.

X-Ray Examination

Left Shoulder shows a triangular epiphyseal infarct which is sharply demarcated as a sclerotic area (Fig. 1). Between it and the joint there is a broad radiolucent zone. Here the joint surface shows a segment which is flattened and slightly irregular. (There is no evidence of osteoarthritis.)

Right Shoulder — The changes here are roughly the same as in the left, there being a smaller area of radiolucency and only slight roughening of the joint surface. (Fig. 2).

Left Hip — The femoral head contains a relatively large triangular infarct. There is a small segment of flattened joint surface and osteoarthritic changes are present. (Fig. 3.) Similar changes are present in the right femoral head and acetabulum.

Both Knees — There are medullary calcifications in the diaphyses of the lower femora and upper tibiae and these are fairly typical in appearance. (Figs. 4, 5 and 6.)

Differential Diagnosis

Epiphyseal bone infarcts are to be distinguished from primary osteoarthritis, osteochondritis and Perthes' disease.

The diaphyseal lesions should be differentiated from osteoid osteoma, Brodie's abscess and the bone infarcts of calcified enchondromas.

In general, the Roentgen findings alone are conclusive; but in some cases biopsy may be required to assure the diagnosis.

Summary

A case of Caisson disease is reported in which there are typical skeletal changes and for which the causative accident occurred during a single morning's employment in high pressure tunnel work approximately 25 years earlier.

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Acknowledgment

The authors desire to thank Dr. Robert Penney for furnishing all the clinical information relative to the above reported case.

BOOKS RECEIVED

Books received are acknowledged in this department and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

Basic Foundation of Isotope Technique for Technicians, edited by Willard C. Smullen, M.D., The Ryerson Press, Toronto, $5.25. Publisher, Charles C. Thomas, Springfield, Ill.

Manual of Radiation Therapy, by K. Wilhelm Stenstrom, Ph.D., The Ryerson Press, Toronto, $5.00. Publisher, Charles C. Thomas, Springfield, Ill.

Medical Radiation Biology, by Friedrich Ellinger, M.D., The Ryerson Press, Toronto, $22.00. Publisher, Charles C. Thomas, Springfield, Ill.

BOOK REVIEW

Traité Technique de Tomographie Osseuse, by Robert Herdner (Bourges), Masson et Cie, Paris, France.

The author is a pioneer in the field of tomography of the skull. In this book he recommends his own method of tomography which is the result of ten years of study. This work is unparalleled in the literature on this subject.

The book is primarily one of technique, designed to illustrate tomography of any portion of the skull. It consists of 404 pages, comprising 338 illustrations. Many original drawings of exceptional clarity are included.

Among the topics discussed are: positioning of the patient, angulation and centreing of the X-ray beam, and interpretation of the radiographs.

The reviewer strongly recommends this book to all radiologists. Although written in French, it should be comprehensible to English-speaking radiologists with a working knowledge of the French language.

L.-P.B.

ENTEROGENOUS CYST OF THE DUODENUM*

R. L. DuBERGER, M.D.
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A little over a year ago, a young girl, aged 14, was referred to us for a gastrointestinal investigation. She was healthy looking, very intelligent and she told the following story.

As far back as she can recall, she has had acute unprovoked attacks of epigastric pain, with or without vomiting, lasting anywhere from a few minutes to twenty-four hours, with spontaneous relief whatever the medication employed. In the intervals between the attacks, she was symptom-free. During childhood these spells occurred four or five times a year. As the years passed they increased in frequency and now occur about twice a month. She was first given worm medication.

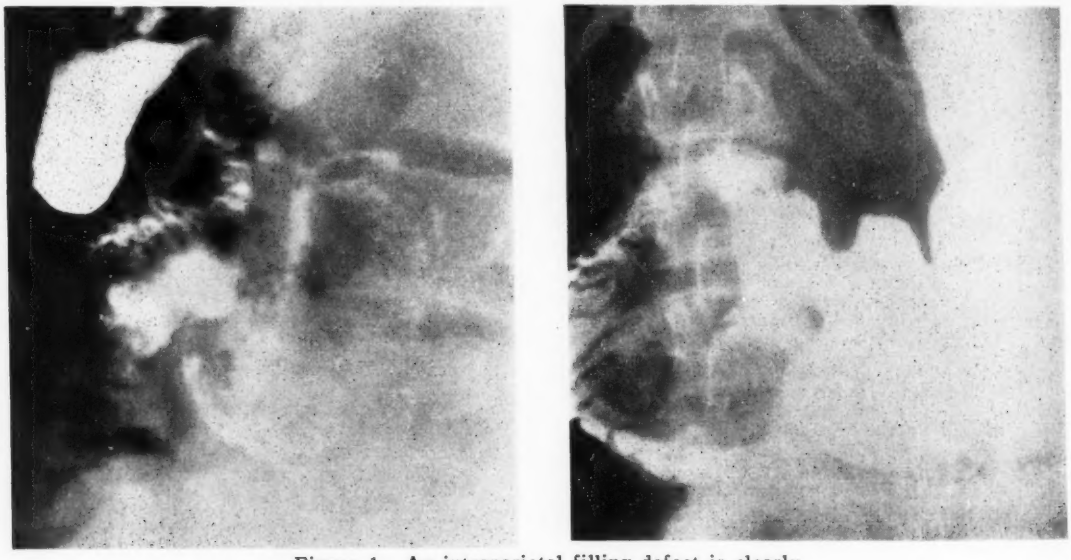

Figure 1. An intraparietal filling defect is clearly seen on the postero-anterior and lateral view of the descending duodenum.

At the age of six her appendix was removed, but there is no record of a full abdominal exploration. Cyclic vomiting and psychoneurotic tendencies were alternately and frequently mentioned, and her mother was told that puberty would set everything right. However, puberty came normally and the attacks continued. Her present attending physician was finally consulted and he took a serious enough view of the case to examine her thoroughly. His physical examination was essentially negative except for one puzzling fact which he mentioned on the X-ray requisition, namely, on abdominal palpation, he felt a deep ill-defined mass above the umbilicus. After palpating elsewhere he returned to this region, but the mass had disappeared; the next day it was there again!

The girl was admitted to St-Vincent de Paul Hospital for a full investigation, including X-ray examination. All laboratory tests were normal. She was given the usual barium mixture. The first swallow passed the pylorus without hesitation, went through the first portion of the duodenum and fell into a cistern-like, widely dilated descending duodenum at the bottom of which it spilled over a smooth rounded mass. (Fig. 1.) This mass occupied the space between the ampulla and the genu inferius. This image persisted throughout the examination. There was delay but no actual obstruction. The mucosal pattern was not destroyed but smoothed out over the mass, and it was quite evident that we were dealing with a benign intraparietal mass. We reported it as such, suggesting the diagnosis of adenoma or leiomyoma. The possibility of cyst was not considered.

An operation was advised. The surgeon found a soft, easily compressible egg-sized mass occupying the posteromesial wall of the duodenum starting at the ampulla, which seemed to enter the top of the mass. The

*Presented at Annual Meeting, The Canadian Association of Radiologists, January 13-17, 1957, Montreal.

consistency of the mass indicated a cyst-like structure. The anterior wall of the duodenum was incised and a needle was inserted into the mass. Aspiration yielded what appeared to be pure bile.

A closer inspection then revealed a thin pipe-like elevation in the anterior wall of the mass leading from the ampulla to an opening into the duodenal lumen through which bile was oozing. This evidently was an elongated ampullar duct. At this stage the surgeon was convinced that he was dealing with a cyst of the ampulla. To be doubly certain and, at the same time, to preserve the ampulla from damage, he opened the bile duct and inserted a probe which entered the cyst cavity without difficulty. He then opened the cyst, removed part of the anterior wall and turned the remaining portion upwards suturing it to itself just below the ampulla so that the inner wall of the cyst now faced into the duodenal lumen. It was while doing this that he noticed that the cyst lining strikingly resembled duodenal mucosa, and he realized that he was dealing with an enterogenous cyst communicating with the biliary system. The rest of the operation was routine and of no interest to radiologists. Post-operative recovery was uneventful and there have been no recurrences of the attacks previously described.

Histological sections (Fig. 2.) of the portion removed from the cyst wall confirmed the diagnosis. The sections show two layers of duodenal mucosa back to back, each with a muscularis mucosae, and separated by a thin band of submucosa common to both. Neither of the layers in any way resembles a biliary lining.

Discussion

Enterogenous cysts are rarities; of this there is no doubt. Schinz[1] and Shanks[2] make no mention of them. In the very complete French "Encyclopédie Medico-Chirurgicale", Porcher and Sauvegrain[3] make this very short statement:

> *There may be, on a segment of varying length, a doubling of the intestinal lumen, a duplication of the bowel. In such a case, one lumen, will be continuous with the bowel above and below, while the other becomes an enterogenous cyst buried in the thickness of the mesentery. This second cavity does not generally communicate with the normal intestine. The diagnosis of this particular type of mesenteric cyst is made as a rule only during a surgical intervention. No illustrations are included.*

The British authors' text makes no reference to this condition. Very short descriptions are given by Templeton[4], Feldman[5] and Ritvo[6], Caffey[7], in the latest edition of his book mentions the cysts, but describes mostly enteric duplications, stating that, "in some cases, they exist as cysts, entirely separated from the alimentary canal." This describes the mesenteric type, but not the intraparietal variety.

In 1934, Hughes-Jones[8] reported an enterogenous cyst involving the jejunum; he found fifty-five cases reported in the literature prior to that date. The lesions were distributed as follows: Duodenum 3, jejunum 4, ileum 16, ileocaecal region 31 and transverse colon 1. He made the interesting comment that duodenal cysts are more likely to be intra-mural, while the others are generally mesenteric.

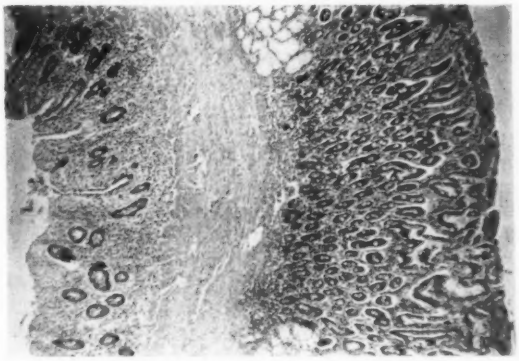

Figure 2. Cross-section of the cyst wall on the mucosal side of the cyst. It is made up of a band of muscularis mucosae on each side of which can be seen duodenal mucosa, thus proving the identity of an enterogenous cyst.

Leaving aside the rest of the alimentary tract to confine our remarks to duodenal cysts, we find that Gardner and Hart[9] reported a case in 1935 concerning a child aged 15. Pachman[10], four years later, found eight cases reported, seven of which were intramural. In 1947, Shallow et al[11] found 13 cases reported to date and added a fourteenth of their own. With the exception of Garner and Hart's case, all had been found in very young infants and surgery was attended by a very high mortality rate. In 1948, Lowndes and Peple[12] found a double cyst involving the duodenal bulb and the genu superius in a woman aged 69. This case is unique and, in our opinion, offers features entirely different from the others. For example, this patient had had numerous previous examinations and none of the films showed the least anomaly in the involved area. Occlusive symptoms dated back only one year and the radiologist reported a large filling defect in the bulb with a definite statement that it was not present previously. No histological report was given and we are convinced that this cyst-like structure, whatever its nature, was not of the type we are discussing now.

In 1950, H. Gordimer[13] reported an extremely interesting case in "Annals of Surgery". This case is fully documented. It concerns a young woman aged 30, in whom the cyst contained not only bile but also a dozen well formed stones. Gordimer states that he has found eighteen cases of duodenal enterogenous cysts reported so far and only three of these contained bile.

As the years go by, more cases are being reported, but they are still very scarce. We have, however, found nothing new concerning the pathogenesis. It is generally believed that enterogenous cysts are developmental defects, parietal duplications. They can be found anywhere in the gastrointestinal tract, even in the oesophagus. Doctor Cote[14] of Quebec recently demonstrated a most interesting case which had the characters of a mediastinal tumour.

In all cases the cyst cavity is lined by a mucosa similar to that of the segment from which it originates. When the cyst is in the mesentery its walls are generally found to contain all four layers of the normal gut. On the other hand, when it lies in the wall, as in our case, its outer layer is complete, but the inner one consists of mucosa and possibly submucosa, but rarely muscularis. In such cases, as we have shown, the section will show two mucosal layers back to back, possibly separated by a common submucosa. This histological picture is pathognomonic.

The symptoms will vary according to the size of the lesion. If the cyst is big enough to occlude the lumen, high obstructive symptoms will appear soon after birth. An early diagnosis is unlikely. The child weakens rapidly, and this no doubt accounts for the high surgical mortality. When the cyst is smaller, the occlusion is incomplete and intermittent, the child grows and may reach the adult age at which time the surgical risk is very slight. If the cyst is mesenteric, it may be symptomless for a long time or may never cause symptoms. When symptoms do appear, they are the same as those of any mesenteric cyst and a pre-operative diagnosis is impossible.

In the present case, we confess that the correct diagnosis did not occur to us. In retrospect, however, one fact does stand out: the mass was not always palpable, showing that the tumour was inconstant. This should have led to a correct diagnosis of a cyst not completely enclosed. If it were enclosed, there would be no means of distinguishing it from any other benign tumour.

In retrospect, we would probably have been wise to do an intravenous cholecystogram, and we regret not having done so.

Summary

1. We have presented a case of duodenal enterogenous cyst communicating with the biliary tract. To our knowledge only four similar cases have been reported in the literature.

2. We have confirmed an opinion previously expressed that these cysts, when they do not cause early obstruction, are compatible with normal growth and constitute excellent surgical risks.

3. Radiological diagnosis of an intraparietal duodenal tumour is fairly easy. Identification of a cyst as such, however, is impossible unless it contains bile and varies in size from day to day or even from hour to hour. If the condition is suspected, an intravenous cholecystogram should be done.

Acknowledgment

We wish to express sincere thanks to Dr. Gaspard Boulay for allowing us to present this case, to Dr. Hector MacDougall for his surgical findings and to Dr. Jacques Olivier for his assistance in the histological diagnosis.

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DOSE TO THE GONADS DURING DIAGNOSTIC PROCEDURES*

F. D. SOWBY, M.D.
Ottawa, Ontario

There has been recent concern about the possible genetic effects of radiation on the human population. It has been known for some years that radiation can induce genetic changes in plants and lower animals, and there is no reason to suppose that similar changes cannot be brought about in humans.

Every living being inherits certain characteristics from his forebears, and through the sperm or ova passes on these characteristics to his descendants. Most of the characteristics are passed on unchanged, but there is a very slow rate of change in these characteristics, which gives rise to evolution. Such changes in characteristics are called "mutations". Mutations can be advantageous or harmful, and in the past natural selection has probably eliminated the harmful characteristics from the population, while the advantageous mutations have been slowly absorbed.

The genetic effects of radiation differ in several respects from the somatic effects. Genetic effects are cumulative, irreparable and permanent, and will not show up in the individual himself, but in his descendants, and mainly in remote rather than immediate generations. For any population the number of genetic effects are directly proportional to the total gonadal radiation dose received by the population. In other words, the genetic effects on a population of 10 million people would be the same whether each one of them received 1 roentgen or one million of them received 10 roentgens.

In short then, one is concerned about the irradiation of a population, and of course it is only those who will reproduce that can pass along the mutations that have been brought about in them.

TABLE I[1]

Summary of estimated population doses of radiation to the gonads expressed as percentages of natural background

Source of radiation	Approximate dose to gonads as a Percentage of natural background
Natural background	100
Diagnostic radiology	at least 22
Radiotherapy	?
Shoe-fitting	0.1
Luminous watches and clocks	1
Television sets	much less than 1
High altitude flying	insignificant
Occupational exposure:	
Radiology and Industry	at least 1.6
Atomic Energy Authority	0.1
Fall-out from test explosions	less than 1

The spontaneous mutation rate can be increased by irradiation of the reproductive tissues, and it can be shown that the increased mutation rate of a population will have a greater effect on the harmful than on the advantageous characteristics. In other words, if the mutation rate increases, the incidence of hereditary disease will also increase. For this reason, geneticists advocate the avoidance of all unnecessary exposure of the gonads or reproductive organs.

During the past few years, many governments have initiated studies to assess the dose received from various sources of radiation. British and American reports[1,2] have supplied interesting data on population doses, and their conclusions have agreed closely. They both indicate that the average dose received from natural background is about 100 millirem per year, but in some parts of the world this level is higher. The dose from fall-out is about 1 millirem per year, and the dose from diagnostic radiology is at least 22 mrem per year, and may be as high as 100 mrem/yr. In other words, diagnostic radiology contributes by far the greatest population dose of man-made radiation, and may double the background dose.

*Presented at Annual Meeting, The Canadian Association of Radiologists, January 13-17, 1957, Montreal.

It is interesting to note in the British report that examinations in the region of the pelvis are responsible for most of the dose received from diagnostic radiology, even though these examinations are not as frequently carried out as, say, chest examinations, in which the dose to the gonads is low.

This brings up an important point in connection with the figures that have been quoted for doses to gonads received from various examinations. The studies on which these figures are based were carried out in a large hospital in which protection, both of staff and of patients, was of the best. The figures quoted are therefore minimum values, and will be higher if proper precautions are not taken. There are indications that the dose to the gonads of children may be higher; investigations of this are being carried out.

TABLE II

X-ray examination	Dose (milliroentgens) received by the gonads		
	Male	Female	Fetal
Teeth	4.75	0.8	0.8
Chest	0.36	0.07	0.07
Gall bladder	1.8	15.6	15.6
Pyelogram	486	1,290	3,210
Pelvis	1,100	210	800
Hip; femur	710	210	800
Sacro-iliac joint	129	713	2,700
Pelvimetry	——	1,280	2,680
Leg, foot	3.5	0.6	0.6

We have seen that the background radiation level may be at least doubled by diagnostic radiological examinations. How does this compare with recommended levels? The British report recommends that the dose from man-made radiation should not exceed twice the background dose, and the American report recommends a maximum dose of about 3 times background. The International Commission on Radiological Protection[3] favors a maximum level for the general population of 5 times background. All of which indicates that the average individual should receive a total of less than 6 - 15 r to the gonads by age 30. However, if the dose can be kept lower, so much the better. In fact, the ideal dose is the lowest possible dose consistent with medical necessity. (Occasional individuals, which would include radiation workers, might receive up to 50 rems to the gonads by age 30, but these individuals should not exceed 1/50 of the population.)

In what ways can the dose to the gonads be kept low?

1. Radiographic examinations should be limited to those that will provide really valuable information. For instance, every effort should be made to avoid having to repeat examinations because of technical faults; records of techniques should be kept so that subsequent films can be taken under comparable conditions.

2. Certain specific examinations, such as those of the pelvis, hips and lower spine should be most rigorously reserved for essential purposes. This is particularly important in pregnant women, where two individuals are irradiated at one time. (There is also a possible additional hazard here of an increased incidence of leukaemia in the offspring[5].)

3. Routine fluoroscopy, particularly of children, should be avoided unless it is thought that real benefit is to be derived from the examination.

4. Technical steps should be taken in every examination to ensure that the dose delivered is the minimum necessary for the examination.[4]

For instance, in the case of fluoroscopy, if a good screen is used the beam dose rate need not exceed 5 r/min at the table top in order to obtain a satisfactory image, and yet one often encounters outputs many times higher. Again, adequate cones to restrict the beam to the part being examined, and filters of at least 2 mm. Al to reduce the useless low energy X-rays, should always be used.

Furthermore, consideration should be given to the wider use of image intensifiers, from which the radiation output can be kept considerably below that of standard X-ray machines.

5. The gonads should be shielded when it is practicable to do so, though this would probably be of chief value during examinations of the male.

6. All who carry out radiographic examinations should know the outputs of their machines under various circumstances, and should be aware of how and why the dose should be kept as low as possible. They should insist that their suppliers provide them with machines that conform to recommended practice[3,4].

It will be noted that the main emphasis of this paper has been on the need for protecting the patient. At the same time much still remains to be done to provide protection for the many users of radiation sources, both amongst the medical profession and elsewhere.

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MEETINGS

The Canadian Association of Radiologists

The Twenty-First Annual Meeting of the Canadian Association of Radiologists will be held in the Hotel London, January 12th - 15th, 1958, as follows:

Sunday, January 12th		**Place**
Meeting of Council	2:00 P.M.	Room 801
Cocktails and Dinner (Members and wives)	6:00 P.M.	To be announced.
Monday, January 13th		
Meeting of Council	9 - 5 P.M.	Room 801
Annual Meeting	7:30 P.M.	Regency Room

(N.B. — The Annual Meeting will now be held on Monday instead of Tuesday evening as announced in Bulletin No. 84, August 28th.)

Tuesday, January 14th		
Scientific Sessions	9 - 5 P.M.	Regency Room
Wednesday, January 15th		
Scientific Sessions	9 - 5:30 P.M.	Regency Room
Reception and Cocktails	6:30 P.M.	Terrace Room
Annual Dinner	7:30 P.M.	Regency Room

Scientific papers:

You are requested to send the title of your paper immediately to: Dr. G. W. Kruger, Woodstock General Hospital, Woodstock, Ontario.

EXHIBITION OF X-RAY APPARATUS

In conjunction with the Annual Congress of the British Institute of Radiology, the British X-ray industry is holding an exhibition of medical X-ray apparatus at the Royal Horticultural Society's Hall, Westminster, London, England, on November 27, 28, and 29, 1957. Tickets are available on request from: The Secretary, British Institute of Radiology, 32 Welbeck Street, London W.1, England.

10th ANNUAL CONFERENCE ON ELECTRICAL TECHNICS IN MEDICINE AND BIDOGY

This Conference will be held November 6, 7 and 8, 1957, at the Sheraton-Plaza Hotel, Boston, Massachusetts.

SMALL PROBE DOSIMETERS*

L. G. STEPHENS-NEWSHAM, Ph.D.
J. LA PALME, M.Sc.
Montreal, Quebec

Introduction

Small probe dosimeters have been used for some years for measurements about radium or in X-ray beams with sharp variations in intensity such as those under grids or in small fields. In the case of radium moulds the dose rate may vary 20 per cent or more in a millimeter so the sensitive volume of the dosimeter should be no more than a few cubic millimeters. The whole probe must be small enough to go into body cavities where measurements are to be made. For clinical use the instrument must be rugged and stable and easy to sterilize. It must be light enough to be easily manoeuverable.

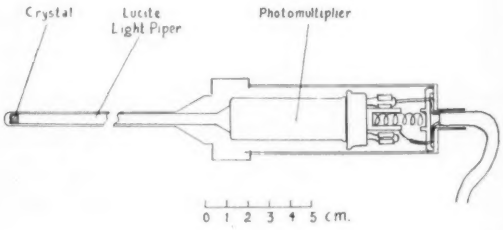
Ionization chambers have been used for this purpose. Turner and Newbery[1] described such a device and its clinical use. A similar probe with a very stable amplifier has been described by Johns, Fedoruk and Watson[2] having a chamber volume of only 0.1 cc. Ion chambers have the advantage of being made air equivalent more easily but the design of very small ones presents problems of high insulation and amplification of very small currents.

The authors have investigated the potentialities of two other principles of radiation detection. The first of these is the fluorescence of certain crystals when subjected to ionizing radiation, and the other is the change in conductivity produced by ionizing radiation in some semi-conductors. Both these properties can be measured electrically and relatively large currents are involved as compared to ionization currents.

A Fluorescence Dosimeter

Several workers have described dosimeters using the fluorescence of crystals. These have all involved a small crystal of the fluorescent material mounted inside the probe near the end, with a "light piper" to conduct the light from the crystal to a sensitive photocell. Photomultipliers are the only type of cell sufficiently sensitive to be usable. Currents of the order of 0.1 microamperes flow and their measurement is fairly simple. The side-window type of photomultiplier such as the 931-A has been used in most of these dosimeters and Fowler[3] has recently given details of a probe made with one of these tubes. To avoid fluorescence of the lucite usually used in the light piper he made the latter out of a hollow polished tube. The sensitive volume was thus restricted to the crystal but there was great loss in sensitivity so that a rather bulky power supply, amplifier and register were required.

A number of substances will fluoresce sufficiently under X-rays or gamma rays to be usable. Bits of ordinary intensifier or fluorescent screen have been used[3]. Single crystals of calcium tungstate work very well though the response is relatively higher for lower energy X-rays. Organic crystals such as anthracene, stilbene and napthalene are more likely to be "air equivalent" but their response at low energies of radiation are relatively low. A judicious combination of these materials can yield a more or less "air equivalent" composite crystal[4].



SCINTILLATION PROBE DOSIMETER

Figure 1

An attempt was made to design a fluorescence probe as small as possible and fulfilling the requirements of sensitivity, stability and rapidity of response. Figure 1 shows a cross-section of this probe. A 6365 photomultiplier was used since it has an end window and is the smallest available. Its gain is lower by a factor of 200 than that of the 931-A but the end window gave improved optical coupling to partially compensate. A resistor bridge drawing only 100 microamperes was employed to apply the appropriate 150 volts per stage to the dynodes so that a low drain high voltage supply could be used. Measurement of the tube current was by measurement of the voltage drop across a ten

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megohm resistor between anode and ground. A rather simple vacuum tube voltmeter circuit was adequate for this and was found to be very stable. It provided for a zeroing adjustment so that the dark current could be balanced out.

A lucite light piper was used for maximum sensitivity. The crystal was 5 mm. in diameter and 5 mm. long and optically coupled to the piper with silicone oil. Increased sensitivity was found to result from wrapping light piper and crystal in aluminum foil.

Crystals of both calcium tungstate and anthracene were used. The latter was found to have almost as much sensitivity as the calcium tungstate due to more efficient light collection and the readings dropped to zero immediately after exposure was terminated whereas the calcium tungstate tended to lag a bit.

Figure 2 shows the instrument's response to Cobalt^{60} radiation. It is seen to be linear over quite a wide range of intensity. A check on a radium source, the dose rate of which was calculated, gave agreement within 10 per cent of the Cobalt response, and this was believed to be the approximate margin of error.

The instrument is now being applied to some clinical work and evaluated for this purpose.

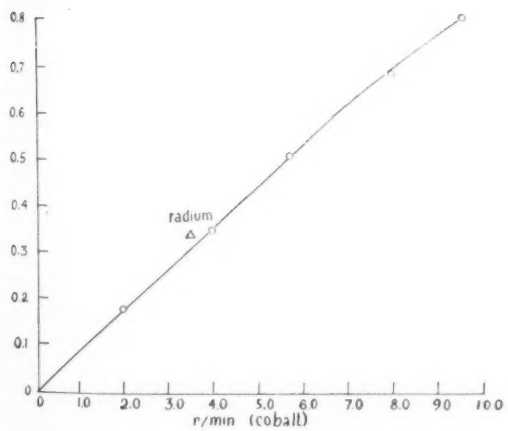

Figure 2

A Photoconductor Dosimeter

Frerichs in 1947[5] and in 1950[6] investigated the conductivity of single crystals of cadmium sulphide under X-ray exposure and suggested their use for measurement of X-rays. More recently Backman, Gelormini and Davis[7] designed a dosimeter probe for the 50 Kv X-ray region. Some time after the present work was undertaken Mauldon and Martin[8] and Hollander[9] reported extensive work on these semiconductors and gave designs of dosimeters using them.

The authors felt that the use of semiconductors offered a very compact, simple and elegant way of measuring dosage in clinical use since they could be made very small, and relatively large electrical currents flowed which could be easily measured. Long flexible leads could be connected to the crystal and the current measured at some distance away.

The crystals of cadmium sulphide are about 2 mm. in diameter and 3 or 4 mm. long. Their resistance is ordinarily several megohms but under exposure to light or X-rays it drops sharply. Electrical connection is made by electrodes painted or soldered onto the ends of the crystal. The action of the crystals is explained by the existence of two types of bands in the crystal. One of these consists of electrons bound to the atoms and the other consists of free electrons. Ordinarily the electrons cannot move due to the attachment in the "filled bands" but under radiation some of them are detached and will move into the "conduction bands" so that the crystal becomes conducting.

A simple circuit consists of a series connection of crystal, a galvanometer and a battery. This will indicate a change in the resistance of the crystal by a change in the current flowing through it. This circuit works well for experimental purposes but is not suitable for portability. To get a robust portable indicator for currents of less than a microampere a simple transistor bridge circuit was developed. This has the advantage of cheapness, low power requirements and sufficient amplification to use a meter of 500 microamperes full scale sensitivity. Two transistors were used in a Turner two stage amplifier with a bridge for zero adjustment.

The probe was designed to go inside a length of plastic tubing 6 mm. in diameter. This was 125 cm. long and flexible so that it could be inserted into body cavities. Several crystals were tried but considerable difficulty was encountered in sealing the electrical connections on to the crystal with silver conducting paint. The soldering method described by Mauldon and Martin[8] shows more promise and is being tried. In the meantime commercially available crystals mounted with soldered leads have been used. These were designed for light detection but have been found to respond to radiation very well. Figure 3 shows details of the probe.

Some experimentation was carried out to find the best operating conditions and a family of curves were plotted giving current versus dose rate for different qualities of radiation. A saturation effect is seen and this depends on the quality of radiation so that the best operating voltage is dependent on the quality of radiation. Saturation is reached earlier for lower energy radiation. Figure 4 shows the variation of current with dose rate for Cobalt^{60} radiation. This is seen to be very linear over a considerable range.

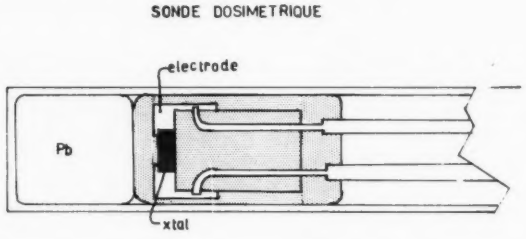

Figure 3

The instrument has not been calibrated absolutely since the application has not required it. A complete energy dependence curve has not been done as yet though preliminary measurements indicate a considerable variation.

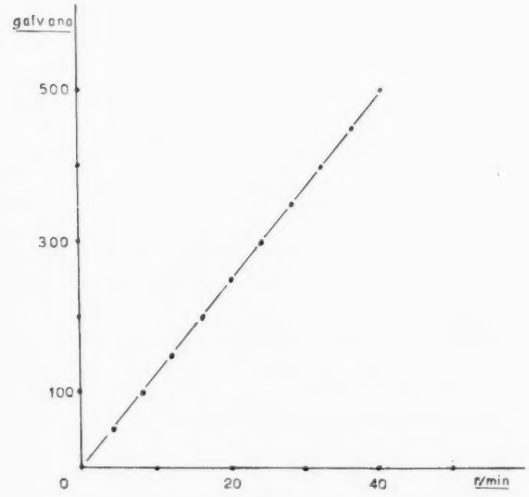

Figure 4

This probe has been used clinically as a centering device in Cobalt Beam Therapy of the œsophagus. The probe is placed in the œsophagus and the patient placed on the treatment table. By successively applying the beam and moving the table an optimum position can be found and skin markings can be applied. This permits greater accuracy with smaller fields. An improvement would be controls for lateral motion of the treatment table from outside the room.

Conclusions

The two types of small probe dosimeters considered here offer many advantages which are worth considering since they permit relatively simple instrumentation to provide a useful clinical instrument with a small sensitive probe.

Summary

As an alternative to ion chamber dosimeters, two other principles of radiation dosage measurement have been investigated and applied to the development of small probe dosimeters. The fluorescence of certain crystals has been applied to the construction of a dosimeter suited for intracavitary work with radium. The variation in conductivity of Cadmium Sulphide has been applied to the construction of a flexible probe for intracavitary work and beam centering.

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